Nov. 15, 1966 E. BAUM 3,286,032

DIGITAL MICROPHONE

Filed June 3, 1963 2 Sheets-Sheet 1

Fig. 1

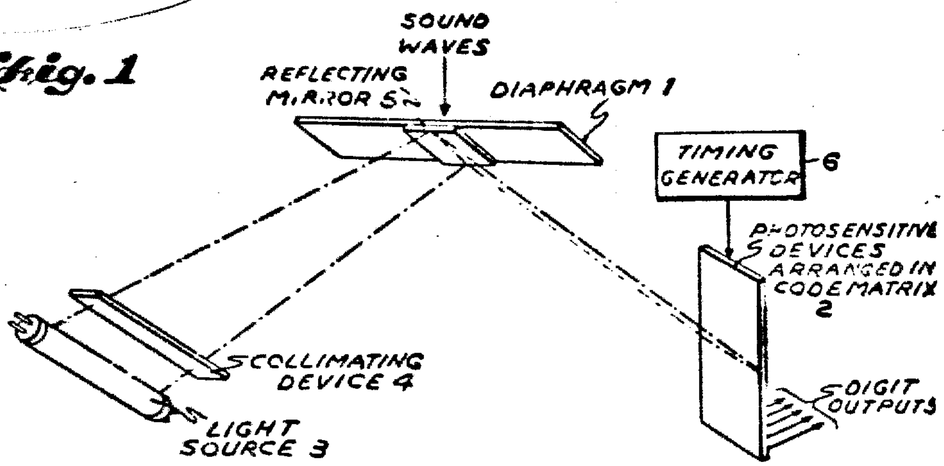

Fig. 3

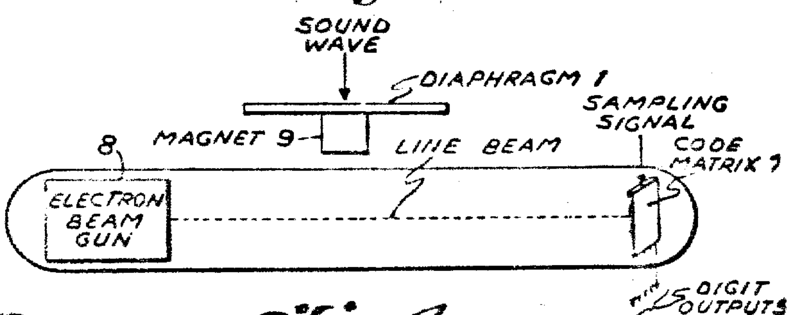

Fig. 2

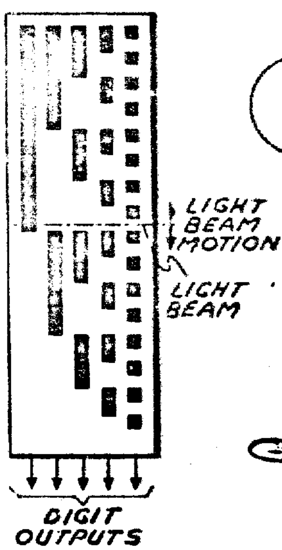

Fig. 4

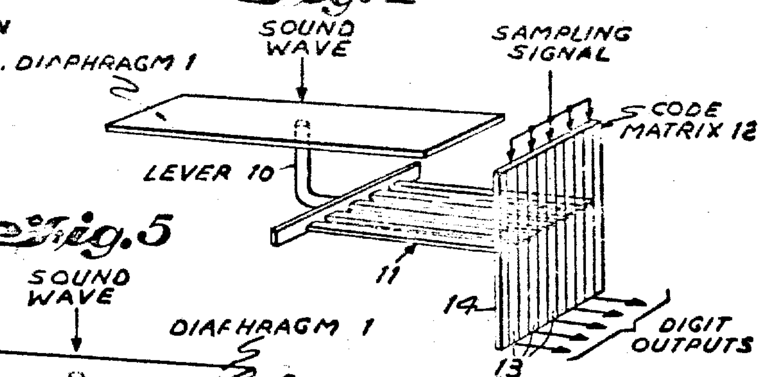

Fig. 5

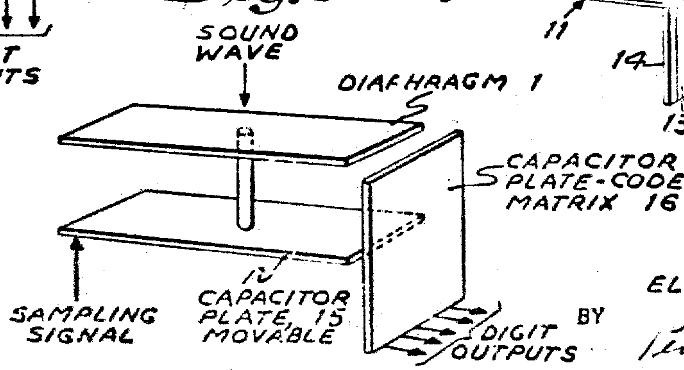

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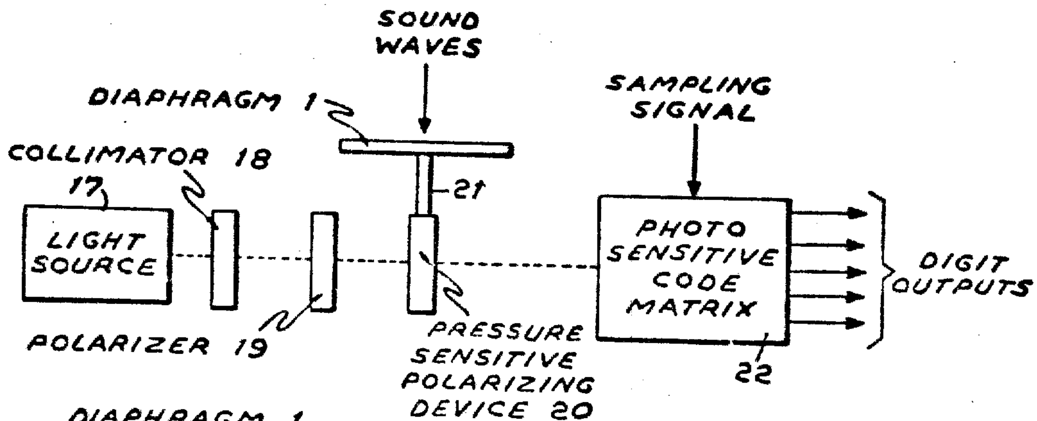
Fig. 6



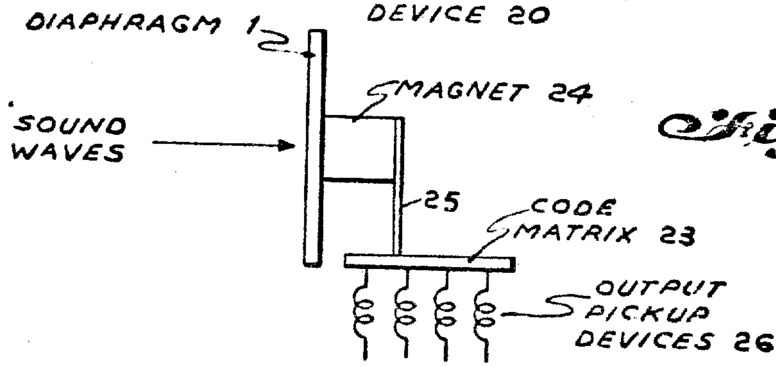
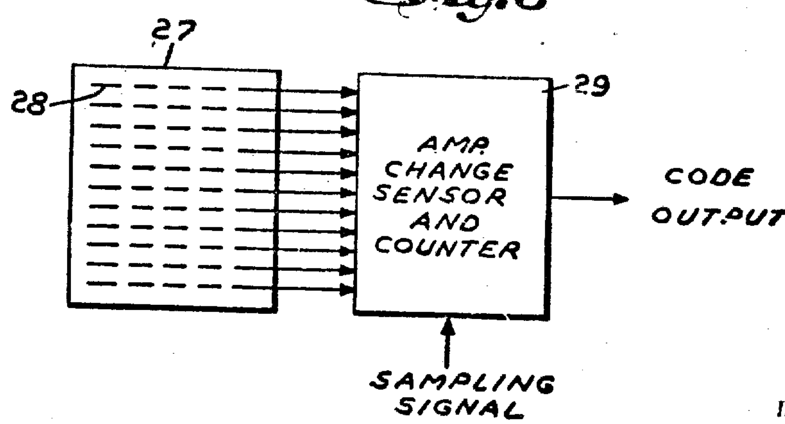


Fig. 7

Fig. 8



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3,286,032
DIGITAL MICROPHONE

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11 Claims. (Cl. 179—1)

This invention relates to microphones and more particularly to a microphone capable of providing directly a digital code output.

In order to transmit sound waves, such as voice, by digital codes, such as PCM (pulse code modulation), it is necessary to transform the voice or sound wave into a pulse coded signal. This is normally done by using an analog type transducer, such as the normal microphone, to translate the sound wave into an electrical output, sample the electrical signal output at regular intervals, and generate a digital code based on the sample of the output wave. If a digital code is to be generated at each subscriber's instrument, the amount of equipment necessary per instrument to do this becomes fairly large.

Therefore, it is an object of this invention to provide a microphone to generate digital code output directly from sound waves.

Another object of this invention is to provide a minimum of equipment at the subscriber's instrument to provide digital coded outputs directly from the sound waves.

Still another object of this invention is to provide a microphone to directly generate a digital code output representative of the sound wave impinging upon the microphone eliminating the double transformation from sound wave to electrical analog and from electrical analog to digital code.

A feature of this invention is to provide a microphone to convert sound waves into a given digital code comprising first means having motion imparted thereto by the sound waves, such as a diaphragm, the motion of the first means being proportional to the amplitude of the sound waves, and second means responsive to the motion of the first means to produce a digital code output according to the given digital code representative of the amplitude of the sound wave, said first and second means being an integral part of the microphone.

Another feature of this invention is the provision of a microphone to convert sound waves into a given digital code comprising a first means having motion imparted thereto by the sound waves, the motion of the first means being proportional to the amplitude of the sound waves, second means arranged according to said given digital code, and third means responsive to the motion of the first means to activate the second means to produce a digital code output representative of the amplitude of the sound waves, said first, second and third means being an integral part of the microphone.

Other features of this invention include the following variations of the second and third means mentioned immediately above. (1) A mirror suspended from the diaphragm to cause a light beam to scan photosensitive devices arranged in a code matrix to generate the digit code output. (2) Polarize a light source and apply the polarized light source to a pressure sensitive polarizing device, said pressure sensitive polarizing device being actuated by the diaphragm to scan the polarized light across a code matrix of photosensitive devices to generate the digit code output. (3) A magnet supported from the diaphragm to scan an electron beam in accordance with the amplitude of the sound wave across a code matrix arranged to be responsive to the electron beam to generate the digital code output. (4) A plurality of brushes supported from a lever attached to the diaphragm to cause the brushes to scan conductive elements arranged in a code matrix to generate the digital code output. (5) A capacitor plate coupled to the diaphragm with the capacitor plate being moved to scan a second capacitor plate in the form of a code matrix to generate the digital code output. (6) Magnetic field sensitive devices arranged to be responsive to the intensity of the magnetic field varying in response to the motion of the diaphragm to generate the digital code output.

A further feature of this invention is the provision of a code matrix in a form other than a straight binary code, for instance delta modulation, inverted binary, excess-3 binary code, and so forth, to provide a digital output in accordance with the given selected code.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates one embodiment of the digital microphone in accordance with the principles of this invention;

FIG. 2 is an illustration of one form which the code matrix of the various embodiments of this invention may assume;

FIGS. 3 through 7 are schematic illustrations of other embodiments of the digital microphone in accordance with the principles of this invention; and

FIG. 8 is an illustration of still another code matrix capable of being employed with the various digital microphone embodiments of FIGS. 1 and 3 to 9.

Basically, all the embodiments of the digital microphone of this invention as will be described hereinbelow, include a first means in the form of a diaphragm having motion imparted thereto by the sound waves, the imparted motion being proportional to the amplitude of the sound waves, a second means arranged in a matrix according to a given digital code, and a third means responsive to the motion of the first means to actuate the second means to produce a digital code output periodically representative of the amplitude of the sound waves.

The term "diaphragm" as used herein is intended to encompass any device, such as a diaphragm of a diaphragm microphone, ribbon or cone, which is caused to move by and in accordance with a sound wave. It includes pressure, velocity and velocity gradient devices.

Referring to FIG. 1, there is illustrated therein diaphragm 1 intercepting sound waves and having motion imparted thereto proportional to the amplitude of the sound wave. A plurality of photosensitive devices are arranged in a code matrix 2 and a source of light 3 is disposed to be projected through a collimating device 4 upon a mirror 5 suspended from or attached to diaphragm 1. Mirror 5 will be moved in accordance with the movement of diaphragm 1. The light from source 3 and collimating device 4 having a line configuration is coupled to mirror 5 and reflected therefrom to scan matrix 2. A timing generator 6 will produce periodic pulses to sample matrix 2 to produce at these periodic samplings the digit outputs in accordance with the given digital code employed. One way of accomplishing the sampling is to have matrix 2 include a plurality of photosensitive devices arranged to be primed by the sampling pulse of timing generator 6 and to pass or gate an output to the digit outputs when excited by the line beam from source 3.

FIG. 2 illustrates a binary code matrix which could be employed as matrix 2 of FIG. 1. The darkened areas constitute the photosensitive devices, such as photoelectric cells, and as illustrated, the light beam in the form of a line beam will be caused to scan this matrix to generate the binary outputs for each digit of the digital code. It is to be understood, however, that this is not the only matrix that can be employed. It would be possible to employ the reflected binary code and any of the

other known types of digital codes presently available in the art. The illustration of FIG. 2 is only for the purpose of an illustrative example and is not meant to limit the scope of this invention.

Referring to FIG. 3, another embodiment of the digital microphone of this invention is illustrated which incorporates a code matrix 7 arranged to be responsive to an electron beam in the form of a line as produced by electron gun 8. Matrix 7 may be in the form of apertures through which the electron beam may pass to impinge upon target electrodes which when sampled to overcome a bias thereon will permit the production of the digit outputs. Matrix 7 may also take the form of elements arranged in the code matrix in accordance with the given digital code to be responsive directly to the electron beam, but biased in such a manner that an output will not be produced until the sampling signal is applied thereto. The line electron beam is caused to sweep matrix 7 by utilizing magnet 9 supported from diaphragm 1 whose motion will cause the magnetic field of magnet 9 to sweep the electron beam across the surface of matrix 7 and, hence, produce the digital code output during the sampling periods as described hereinabove.

Referring to FIG. 4, there is illustrated therein still another embodiment of the digital microphone of this invention which incorporates therein diaphragm 1 to intercept the sound wave and having motion imparted thereto by the sound wave. This motion is imparted to lever 10 secured to diaphragm 1. Lever 10 carries thereon a plurality of brushes or contacts 11 equal in number to the digits of the digital code which are caused to sweep code matrix 12 in the form of conductors arranged in accordance with the particular digital code. Matrix 12 is sampled by the sampling signal from generator 6 and the position of contacts 11 on matrix 12 will determine the digit output for the given digital code. For instance, the sampling signal will be coupled to each conductor forming the code matrix secured to the front face of a dielectric sheet 14 and the brushes will act to connect these conductors to a solid line conductor 13 secured to the opposite face of the dielectric sheet 14 for each of the code digits. This will act to complete the circuit between the conductors arranged in the code configuration and the solid line conductors 13. Another modification would be in the form of a dielectric sheet having apertures therein arranged in the code matrix and conductors 13 behind the apertures of each digit of the given digital code. The sampling signal would then be applied to contacts 11. When contacts 11 sense an aperture the circuit is completed to conductors 13. Many other variations of the sampling of the code matrix to generate the digit pulses will become immediately apparent to those skilled in the art.

Referring to FIG. 5, there is illustrated therein still another form which the digital microphone of this invention can assume. Again, diaphragm 1 acts to intercept the sound wave and having motion imparted thereto proportional to the amplitude of the sound wave. This motion is then imparted to movable capacitor plate 15 which is caused to scan a code matrix formed from a plurality of individual conductors arranged in accordance with the particular digital code. Thus, the fixed capacitor plate forming the code matrix 16 and the movable capacitor plate 15 are capacitively coupled together and when plate 15 is sampled by the sampling signal from generator 6, appropriate outputs are produced at the digit outputs in accordance with the amplitude of the motion and, hence, the amplitude of the sound wave at the time of sampling.

FIG. 6 illustrates still another embodiment of the digital microphone of this invention including a light source 17 and a collimator 18 to produce a beam which is acted upon by polarizer 19 in the form of a "Polaroid" or similar polarizer with the polarized light energy being passed through pressure sensitive polarizing device 20. Device 20 is coupled to diaphragm 1 to respond to the motion of diaphragm 1 through motion to pressure transducer 21. The action of devices 19 and 20 may be described as follows to cause the light beam of source 17 to illuminate only that part of matrix 22 which describes the instantaneous amplitude of the input sound wave. This is accomplished by configuring pressure sensitive polarizing device 20, by shaping and stressing it, so that at only one line, perpendicular to the applied diaphragm force, is the polarization the same as that of the polarized incident light from device 19. The position of this line varies with the applied stress from diaphragm 1 such that the light passing through device 20 illuminates only the portion of the photosensitive code matrix 22 which represents the instantaneous force applied by diaphragm 1 and, hence, the amplitude of the sound wave.

FIG. 7 illustrates still another embodiment of the digital microphone of this inventon including magnetic field sensitive devices of solid state nature of magnetic material arranged in accordance with a given digital code to form a code matrix 23. Matrix 23 may have the configuration illustrated in FIG. 2 where the darkened areas represent the magnetic material or solid state magnetic field sensitive material. A magnet 24 is secured to diaphragm 1 to move in accordance with the movement of diaphragm 1. The movement of magnet 24 is imparted to arm 25 of magnetic material to scan matrix 23. The magnetic field present in arm 25 saturates that particular portion of matrix 23 representing the magnitude of movement of diaphragm 1 and, hence, the amplitude of the sound wave. Output pickup devices 26, such as coils or solid state device, for instance, Hall effect devices, are magnetically coupled to matrix 23 and will respond to that saturated portion of matrix 23 to produce the digital code output. If magnet 24 is an electromagnet and pulsed by the sampling signal, the output devices 26 may be coils to sense the presence of the magnetic field.

In all the digital microphones described hereinabove it is possible to insert sound wave amplifiers between the source of sound wave and diaphragm 1 to increase its sensitivity. Also, either in an amplifier following the digital output or by means of the arrangement of the code matrix it is possible to provide an amplitude compression at the microphone.

Another possible variation is in the code matrix itself wherein it is desired to transmit the digital code output in the form of delta modulation rather than the generally well known binary code type digital outputs. One method of achieving this is to employ in conjunction with any of the motion transducers described hereinabove a matrix 27 wherein the maximum allowable amplitude is divided into a number of discrete levels 28 which may be equal or unequal. The microphone is arranged to produce an output for each of the levels in such a manner as to produce a positive signal as each level is reached in increasing amplitude and a negative output as each level is reached in a decreasing amplitude. These signals may be used to operate a counting device whose output is in the desired coded form. As illustrated in FIG. 8, amplitude change senser and counter 29 will cooperate with matrix 28 to produce the positive and negative signals as described hereinabove. Each of levels 28 will have applied thereto a different value of voltage and the amplitude change senser detects whether the voltage increases or decreases as the microphone scanning arrangement moves from one level to another. The output of this senser then actuates the counter to produce the desired digital code output.

Fiber optics may be used to improve the performance or simplify the construction of the schemes dependent on light.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope

of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A microphone to convert sound waves into a given digital code comprising:
first means integral with said microphone having motion imparted thereto by said sound waves, said motion being proportional to the amplitude of said sound waves; and
second means integral with said microphone responsive to said motion of said first means to produce a digital code output according to said given digital code representative of the amplitude of said sound waves.

2. A microphone to convert sound waves into a given digital code comprising:
first means integral with said microphone having motion imparted thereto by said sound waves, said motion being proportional to the amplitude of said sound waves;
second means integral arranged with said microphone arranged according to said given digital code; and
third means integral with said microphone responsive to said motion of said first means to activate said second means to produce a digital code output representative of the amplitude of said sound waves.

3. A microphone according to claim 2, wherein said first means includes a diaphragm.

4. A microphone according to claim 2, wherein
said second means includes
photosensitive devices; and
said third means includes
a light beam responsive to said motion of said first means to activate predetermined ones of said devices to produce said digital code output.

5. A microphone according to claim 4, wherein
said third means includes
a mirror attached to said first means to sweep said light beam across said devices in accordance with said motion of said first means.

6. A microphone according to claim 4, wherein
said third means includes
a light polarizer to impart a given polarization to said light beam; and
a pressure sensitive light polarizing device attached to said first means to control the portion of said photosensitive devices said polarized light beam illuminates in accordance with said motion of said first means.

7. A microphone according to claim 2, wherein
said second means includes

a target assembly including means arranged according to said given digital code; and
said third means includes
an electron gun projecting a line electron beam to said target assembly, and
a magnetic means carried by said first means to sweep said beam across said assembly to activate predetermined ones of said target assembly means to produce said digital code output.

8. A microphone according to claim 2, wherein
said second means includes
a group of conductors arranged according to said given digital code; and
said third means includes
conductive means carried by said first means in juxtaposition to said group of conductors to produce said digital code output during predetermined sampling periods.

9. A microphone according to claim 8, wherein
said conductive means includes
a plurality of brushes equal in number to the digits of said digital code output in contact with said group of conductors; and
said second means includes
means to periodically sample said group of conductors.

10. A microphone according to claim 8, wherein
said conductive means includes
a conductive plate capacitively coupled to said group of conductors; and
said third means includes
means to periodically sample said plate.

11. A microphone according to claim 2, wherein
said second means includes
magnetic field sensitive devices; and
said third means includes
magnetic field producing device coupled to said first means having its position varied in accordance with said motion of said first means.

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